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Technical Specification

**Digital Video Broadcasting (DVB);
Framing structure, channel coding and modulation of
a carrier identification system (DVB-CID)
for satellite transmission**

EBU
OPERATING EUROVISION

DVB
Digital Video
Broadcasting

Reference
DTS/JTC-DVB-323

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ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00   Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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Foreword

This Technical Specification (TS) has been produced by Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

European Broadcasting Union
CH-1218 GRAND SACONNEX (Geneva)
Switzerland
Tel: +41 22 717 21 11
Fax: +41 22 717 24 81

The Digital Video Broadcasting Project (DVB) is an industry-led consortium of broadcasters, manufacturers, network operators, software developers, regulatory bodies, content owners and others committed to designing global standards for the delivery of digital television and data services. DVB fosters market driven solutions that meet the needs and economic circumstances of broadcast industry stakeholders and consumers. DVB standards cover all aspects of digital television from transmission through interfacing, conditional access and interactivity for digital video, audio and data. The consortium came together in 1993 to provide global standardization, interoperability and future proof specifications.

Introduction

Radio Frequency Interference (RFI) is the largest single issue that impacts Quality of Service for satellite operators and their customers. This in particular applies to occasional use satellite transmissions and temporary feeder links, rather than to full time DTH services where the owners and locations of the uplinks are well known and identified by the respective DVB-SI data.

Whilst RFI can come from many sources, various satellite operators have confirmed that a significant amount of interference comes from so-called "rogue carriers". These are often caused by failed equipment or by a system improperly configured due to human error.

Various actions are being taken by operators, customers, vendors and industry groups to tackle interference, including: training for installers and operators; data sharing to improve operational processes; and new innovations such as Carrier Identification (CID).

Carrier ID is not expected to be a perfect solution to solve all RFI, but it will be a key technology in contributing to the rapid identification of RFI and reducing its negative impact on operators, customers, and the satellite industry as a whole.

Carrier ID will enable the operators and users to:

- Quickly identify interfering carriers and respond to RFI, reducing the duration of each event.

- Improve Quality of Service and reduce operating costs.

- In the longer term, lower the number of RFI events and release bandwidth being used to overcome current and ongoing RFI events.

1   Scope

The present document describes the modulation, channel coding and signalling protocol system (denoted the "System", "DVB Carrier Identification" or "DVB-CID" for the purposes of the present document) intended for the identification of the host carrier it belongs to.

The system uses Binary Phase Shift Keying (BPSK) spread spectrum modulation, differential encoding, scrambling and a concatenated error protection strategy based on repetition, cyclic redundancy check (CRC) and Bose and Ray-Chaudhuri (BCH) codes.

The present document:

- Gives a general description of the system for the transmission of the identification information of a host carrier.

- Specifies the digitally modulated signal in order to allow compatibility between pieces of equipment developed by different manufacturers. This is achieved by describing in detail the signal processing principles at the modulator side, while the processing at the receive side is left open to different implementation solutions.

- Identifies the global performance requirements and features of the System, in order to meet the quality targets for identification of the host carrier.

The system has been optimized for satellite applications including DVB-S, DVB-DSNG and DVB-S2, but can be applied to any continuous transmission by satellite. The system is to be used when no other suitable means of identifying the transmitter are available; such means include but are not limited to remote-control facilities that can switch the transmitter on and off.

2   References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

2.1   Normative references

The following referenced documents are necessary for the application of the present document.

[1]   IEEE standards association, EUI-64 Guidelines, Guidelines for 64-bit Global Identifier (EUI-64™) Registration Authority.

NOTE: Available at: http://standards.ieee.org/develop/regauth/tut/eui64.pdf.

[2]   Recommendation ITU-T E.123: "Notation for national and international telephone numbers, e-mail addresses and Web addresses".

[3]   Intelsat Earth Station Standard IESS-308 (Rev 10): "Performance Characteristics for Intermediate Data Rate Digital Carriers using Convolutional Encoding/Viterbi Encoding and QPSK Modulation".

2.2   Informative references

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1]   IETF RFC 2373 (July 1998): "IP Version 6 Addressing Architecture".

[i.2]   National Marine Electronic Association, NMEA 0183.

3   Definitions, symbols and abbreviations

3.1   Definitions

For the purposes of the present document, the following terms and definitions apply:

CID carrier: transmission signal that transports the Content ID

content ID: possible content of information field carried by CID

NOTE: As described in clause 4.2.

DVB CID global unique identifier: unique identifier for the modulator that transmits the host carrier

hexadecimal representation: representation of a sequence of octet values in which the values of the individual octets are displayed in order from left to right, with each octet value represented as a two-digit hexadecimal numeral, and with the resulting pairs of hexadecimal digits separated by colons

NOTE: The order of the hexadecimal digits in each pair, and the mapping between the hexadecimal digits and the bits of the octet value, are derived by interpreting the bits of the octet value as a binary numeral using the normal mathematical rules for digit significance.

host carrier: transmission signal that is identified by the DVB CID

3.2   Symbols

For the purposes of the present document, the following symbols apply:

α	Roll-off factor
A	the signal identified by the CID
B	the signal being interfered
$C_{0,B}^{*}$ [W/Hz]	signal B power spectral density, at the E/S where the CID is decoded
c_i	chip
comp_factor_CID$_A$ [dB]	Compensation factor to be added to the link budget target SNIR in order to reach a target SNIRA+CID total level equal to the SNIRA when no CID would have been present
D(x)	BCH FEC code message polynomial
Deg$_A$ [dB]	Degradation of the link budget when a CID is added to an existing link
f_0	Carrier frequency
f_N	Nyquist frequency
$G_{BCH}(x)$	BCH FEC code generator polynomial
$G_{CRC8}(x)$	CRC-8 generator polynomial
$g_1(x),g_2(x),...,g_6(x)$	polynomials to obtain BCH FEC code generator polynomial
GF	Galois Field
I, Q	In-phase, Quadrature phase components of the modulated signal
N_0^{*} [W/Hz]	noise power spectral density, at the E/S where CID is decoded
P(x)	BCH FEC code parity polynomial

PSD_{CID} [dB]	the power density level of the CID signal relative to the power density of A
R_A [ksps]	the symbol rate of signal A
R_C	chip rate
$SNIR_A$ [dB]	the Es/(No+Io) threshold for the coding and modulation scheme used by signal A (in the absence of a carrier-ID nuisance signal)
$SNIR_{A+CID}$ [dB]	Overall link budget result as signal to noise and interference ratio with all noise and interference degradations and impact
R_B [ksps]	the symbol rate of signal B
Rc [ksps]	the chip rate of the CID signal that identifies A
T_s	symbol period
SF []	the spreading factor for the CID signal
SNR_{CID} [dB]	the Es/(No+Io) threshold for the coding and modulation scheme used by for the carrier-ID signal, after despreading and assuming diff. coherent detection
y_i	modulation symbol

3.3   Abbreviations

For the purposes of the present document, the following abbreviations apply:

ASCII	American Standard Code for Information Interchange
BCD	Binary Coded Decimal
BCH	Bose, Ray-Chaudhuri, Hocquenghem code
BPSK	Binary Phase Shift Keying
CID	Carrier Identification
CRC	Cyclic Redundancy Check
CRC8	Cyclic Redundancy Check with 8 bits
DTH	Direct To Home
DVB	Digital Video Broadcasting Project
DVB-CID	DVB Carrier Identification
DVB-DSNG	DVB System for Digital Satellite News Gathering
DVB-S	DVB System for satellite broadcasting
DVB-S2	second generation DVB System for satellite broadcasting and unicasting
DVB-SI	DVB Service Information
EBU	European Broadcasting Union
EUI	Extended Unique Identifier
FEC	Forward Error Correction
GF	Galois Field
ID	IDentifier
IEEE	Institute of Electrical and Electronics Engineers
LFSR	Linear Feedback Shift Register
LSB	Least significant bit
MAC	Media Access Control
MSB	Most significant bit
OUI	Organizationally Unique Identifier
PSD	Power Spectral Density
RFI	Radio Frequency Interference
SSB	Single Side Band
TX	Tansmitter
UW	Unique Word

4   Host Carrier identification information

The following specifies the host carrier identification information that is transported by the CID carrier.

The information that identifies the host carrier contains mandatory the DVB CID Global Unique Identifier, fixed by the equipment manufacturer, that shall not be editable by the user, and the CID format revision code (Content ID 0). Additionally it may contain other information that is configurable by the user, identified by different Content ID fields.

4.1   DVB CID Global Unique Identifier

The 64-bit DVB CID Global Unique Identifier is based on the IEEE-defined 64-bit extended unique identifier (EUI-64 [1]) and is sent in two parts of 32 bits. It can be derived from a 48 bit MAC address or a 48 bit Space Data Association modulator identifier as described below.

A 48 bit MAC address assigned to a modulator can be unambiguously sent in the same 64 bit field that specifies an IEEE EUI-64 [1]. The process is also described in Appendix A of RFC 2373 [i.1]. The process is illustrated as follows.

An EUI-48 MAC is composed of 2 sections, a 24 bit manufacturer's IEEE-assigned company ID (for OUI-24) followed by the 24 bit extension identifier:

EXAMPLE 1:   00:06:B0:01:AC:07

                        Manufacturer ID 00:06:B0

                        Extension   01:AC:07

An equivalent EUI-64 starts with the same manufacturer ID, but adds 2 additional bytes of extension identifier. EUI-64 can also accommodate an OUI-36 manufacturer ID with a 28 bit extension identifier.

In either case, there is a restriction on bytes 4 and 5, that shall never be set to either 0x"FFFF" or 0x"FFFE". This is used in the standard as a means of encapsulating a 48 bit MAC into the 64 bit field:

EXAMPLE 2:   00:06:B0:FF:FF:01:AC:07 is parsed as:

                        Manufacturer ID   00:06:B0

                        Added Bytes   FF:FE   Code identifies a 48 bit MAC (EUI-48)

Or:

                        Added Bytes   FF:FF Code identifies a 48 bit MAC (MAC-48)

                        Extension   01:AC:07

To be noted that the two least significant bits of the most significant byte of the 48 bit MAC address shall always be equal to 0: multicast off and globally unique (OUI enforced).

Alternatively, instead of a 48 bit MAC address, a 48 bit Space Data Association assigned modulator identifier can be encoded as a MAC-48, but the least significant bit of the most significant byte shall be set to zero (=unicast) and the second-least-significant bit of the most significant byte shall be set to one (=locally administered).

NOTE: To make sure that the DVB CID Global Unique Identifier is unique, the 'locally administered' are to be assigned by Space Data Association.

Where the DVB CID Global Unique Identifier is shown on the device (printed on a label, displayed on a command line interface, displayed on a graphical user interface) the representation shall be a string of 9 octects starting with a check_digits_octet followed by the octets of the DVB CID Global Unique Identifier starting with the most significant octet, using the hexadecimal representation. The check_digits_octet is a CRC8 covering the bits of the DVB CID Global Unique Identifier with the most significant bit first:

EXAMPLE 3:   The format of the displayed DVB CID Global Unique Identifier is then:

                        CC:XX:XX:XX:XX:XX:XX:XX:XX

                        Where C are the hexadecimal digits of check_digits_octet and X 16 hexadecimal digits of the octets of the DVB CID Global Unique Identifier.

EXAMPLE 4:   The DVB CID Global Unique Identifier 00:06:B0:FF:FF:01:AC:07 will then be shown as:

                        75:00:06:B0:FF:FF:01:AC:07

When the DVB CID Global Unique Identifier is entered by a human (for example for adding an entry to the CID database), it shall be prepended by this check_digits_octet and the human shall be notified if the check_digits_octet does not match with the following octets of the DVB CID Global Unique Identifier.

4.2   Content ID table

The Content ID table (see table 1) lists the possible content of the Information field carried by CID. The CID format revision code (Content ID 0) shall be transmitted; other information is optional, and the Content ID value indicates the corresponding Information field content. If the telephone is sent, all 3 Telephone content ID fields shall be sent. If the User Data is sent, all 7 User Data fields shall be sent.

Table 1: Content ID

Content ID table	
Content ID Value	**Information field content**
0	Carrier ID Format (23:0) CID Format is a revision code anticipating possible changes in the number and possible content of the Fields. This shall be set to 0x000001. All other values are reserved.
1	Latitude(23:4) and (0) Latitude(3:1) are unused and set to '000' Interpreted based on NMEA 0183 [i.2]protocol of degrees and decimal minutes. The field is interpreted as 6 numerical digits in binary form, plus a single bit assigned as "0" = N and "1" = South latitude. For example: 8959.99 N or 89°59'59.4" N would be coded in 24 bits as 110110101011111111110000 and 1245.9 S or 12°45'54" S would be coded in 24 bits as 000111100110101011100001. Resolution is equivalent to 20 meters.
2	Longitude(23:3) and (0) Longitude(2:1) is unused and set to '00' Interpreted based on NMEA 0183 [i.2]protocol of degrees and decimal minutes. The field is interpreted as 7 numerical digits in binary form, plus a single bit assigned as "0" = E and "1" = W longitude. For example: 17959.99 W or 179°59'59.4" W would be coded in 24 bits as 110110110011110011111001 and 2334.45 E or 23°34'27" E would be coded in 24 bits as 000111000111111100101000. Resolution is equivalent to 20 meters.
3	Telephone 1 of 3: (23:0): field is 72 bits made up of 18 x 4 bit BCD coded characters. This field is user entered. Telephone 1 (23) is the MSB of the BCD code of the first digit of the telephone number while Telephone 3 (0) is the LSB of the BCD code of the last digit of an 18 digit telephone number. The telephone number is in international format according to Recommenation ITU-T E.123 [2] with three modifications: '+', "ext." and padding. The '+' sign is not transmitted. In case of an extension, "ext." will be transmitted as binary code "1101". Telephone numbers that do not completely fill the 72 bits are appended with the appropriate number of bits to fulfil the 72 bit filed with the invalid BCD code '1111' (padding). The full table with used BCD codes is in table 2. EXAMPLE: +1 480 333 2200 ext. 1835 would be coded as 000101001000000000110011001100100010000000001101000110000011010111111111
4	Telephone 2 of 3: (23:0).
5	Telephone 3 of 3: (23:0).
6	User Data 1 of 7 (23:0) This field is 168 bits made up of 24 x 7 bit ASCII characters. It allows the operator to enter a user message. This field is user entered. User Data 1 (23) is the MSB of the ASCII code of the 1st character. User Data 7 (0) is the LSB of the ASCII code of the last (24th) character. Used Data that does not completely fill the 168 bits are appended with the appropriate number of bits to fulfil the 168 bit filed with binary '0's (padding).
7	User Data 2 of 7 (23:0).
8	User Data 3 of 7 (23:0).
9	User Data 4 of 7 (23:0).
10	User Data 5 of 7 (23:0).
11	User Data 6 of 7 (23:0).
12	User Data 7 of 7 (23:0).
13 - 31	Undefined.

Table 2: Coding of the telephone number

Phone number symbol or padding	BCD 8 4 2 1
'0'	0 0 0 0
'1'	0 0 0 1
'2'	0 0 1 0
'3'	0 0 1 1
'4'	0 1 0 0
'5'	0 1 0 1
'6'	0 1 1 0
'7'	0 1 1 1
'8'	1 0 0 0
'9'	1 0 0 1
'ext.'	1 1 0 1
Padding	1 1 1 1

The content ID shall be sent in a repetitive sequential manner (starting from the lowest Content ID value and ending with the highest Content ID value) for any Content ID fields that are populated with data. If the total number of populated content ID fields is odd, another Content ID field "0" shall be appended at the end of sequence, to make the number even. Each frame contains two content ID fields.

NOTE: Content ID 0 is a mandatory filed that is sent per the sequence rules below.

EXAMPLE 1: Using the Content ID table above if a user only entered their telephone number into the modulator and did not enter any other information, the sequence becomes 0-3-4-5. The frames sent would be as follows:

- Frame N => Content ID "0" and Content ID "3"

- Frame N+1 => Content ID "4" and Content ID "5"

- Frame N+2 => Content ID "0" and Content ID "3" (restart from the beginning)

- Frame N+3 => Content ID "4" and Content ID "5"

- Frame N+4 => Content ID "0" and Content ID "3" (restart from the beginning)

EXAMPLE 2: Using the Content ID table above if a user did not enter any optional information, the sequence becomes 0-0 (another Content ID field "0" was added to make the total number even). The frames sent would be as follows:

- Frame N => Content ID "0" and Content ID "0"

- Frame N+1 => Content ID "0" and Content ID "0" (restart from the beginning)

- Frame N+2 => Content ID "0" and Content ID "0" (restart from the beginning)

EXAMPLE 3: Using the Content ID table above if a user only entered Latitude and longitude information and did not enter any other information, the sequence becomes 0-1-2-0 (another Content ID field "0" was added to make the total number even). The frames sent would be as follows:

- Frame N => Content ID "0" and Content ID "1"

- Frame N+1 => Content ID "2" and Content ID "0"

- Frame N+2 => Content ID "0" and Content ID "1" (restart from the beginning)

- Frame N+3 => Content ID "2" and Content ID "0"

- Frame N+4 => Content ID "0" and Content ID "1" (restart from the beginning)

5   DVB CID construction

The Carrier ID Transmitter Block diagram is shown in figure 1. It shall be possible to disable the CID in an equipment by hardware or software.
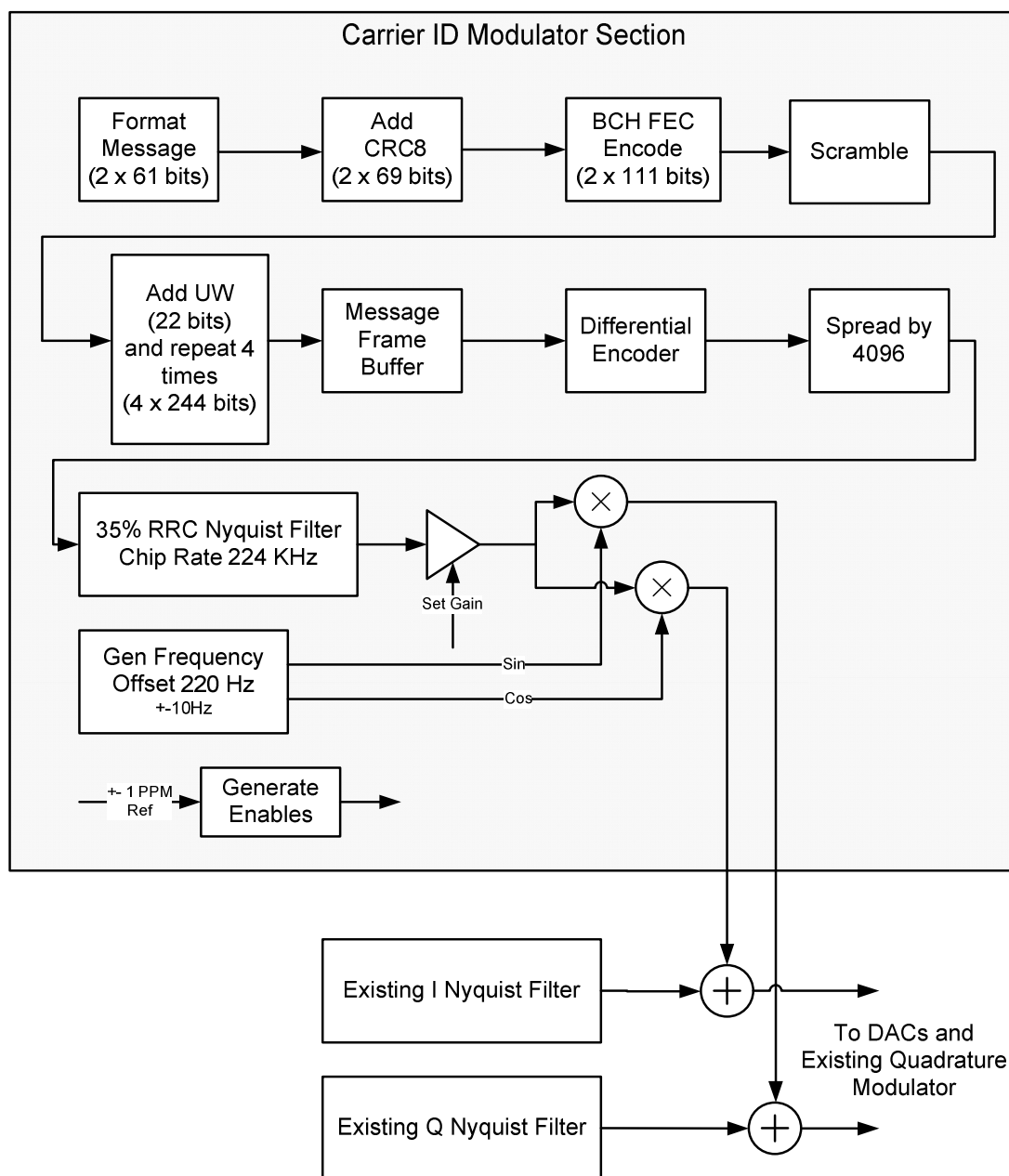

Figure 1: An example Carrier ID transmission block diagram

5.1   DVB CID frame construction

5.1.1   DVB CID Frame format

The syntax and semantics of the CID_Frame are defined in table 3. This CID_Frame will contain the DVB CID Global Unique Identifier and 2 content ID's.

Table 3: Syntax and semantics

Syntax	No. of bits	Mnemonic
CID_Frame () {		
unique_word	22	bslbf
id_high	32	uimsbf
content_id_1	5	uimsbf
content_id_information_1	24	uimsbf
crc_1	8	rpchof
fec_1	42	bslbf
id_low	32	uimsbf
content_id_2	5	uimsbf
content_id_information_2	24	uimsbf
crc_2	8	rpchof
fec_2	42	bslbf
}		
NOTE: id_high and id_low are transmitted in most significant bit first order here, on Ethernet the least significant bit of the most significant byte is transmitted first.		

The semantics of CID_Frame are as follows (see table 3):

unique_word: The unique word (UW) is a 22-bit unique word set alternatively to (MSB first) 0x147147 and 0x2b8eb8.

id_high: The 32 most significant bits of the DVB CID Global Unique Identifier.

content_id_1: Contains the content ID value that indicates what the content_id_information_1 field content will be (see table 2).

content_id_information_1: Contains the Information field content for the Content ID value specified in content_id_1 (see table 2).

crc_1: The CRC8 covers the bits in the id_high, content_id_1, and content_id_information_1 fields in that sequence. See clause 5.1.2 for the details for CRC8 calculation.

fec_1: The BCH FEC covers the id_high, content_id_1,content_id_information_1 and crc_1. See clause 5.1.3 for the details on BCH FEC calculation.

id_low: The 32 least significant bits of the DVB CID Global Unique Identifier.

content_id_2: Contains the content ID value that indicates what the content_id_information_2 field content will be (see table 2).

content_id_information_2: Contains the Information field content for the Content ID value specified in content_id_2 (see table 2).

crc_2: The CRC8 covers the bits in the id_low, content_id_2, and content_id_information_2 fields in that sequence. See clause 5.1.2 for the details for CRC8 calculation.

fec_2: The BCH FEC covers the id_low,content_id_2, content_id_information_2 and crc_2. See clause 5.1.3 for the details on BCH FEC calculation.

5.1.2   CRC8

The calculation below for CRC-8 shall be used for crc_1 and crc_2 in CID_Frame (see clause 5.1.1 and table 3), and for the creation of the check_digits_octet when displaying a DVB CID Global Unique Identifier (see clause 4.1). The CRC8 is a systematic 8-bit CRC encoder. The generator polynomial shall be:

$$G_{CRC8}(X) = (X^5+X^4+X^3+X^2+1)(X^2+X+1)(X+1) = X^8+X^7+X^6+X^4+X^2+1$$

The CRC encoder output shall be computed as:

$$CRC = remainder\ [X^8\ u(X): G_{CRC8}(X)]$$

Where u(X) is the input sequence to be systematically encoded. Figure 2 gives a possible implementation of the CRC generator by means of a shift register.

The register shall be initialized to all ones (0xFF) before the first bit of each sequence enters the circuit.
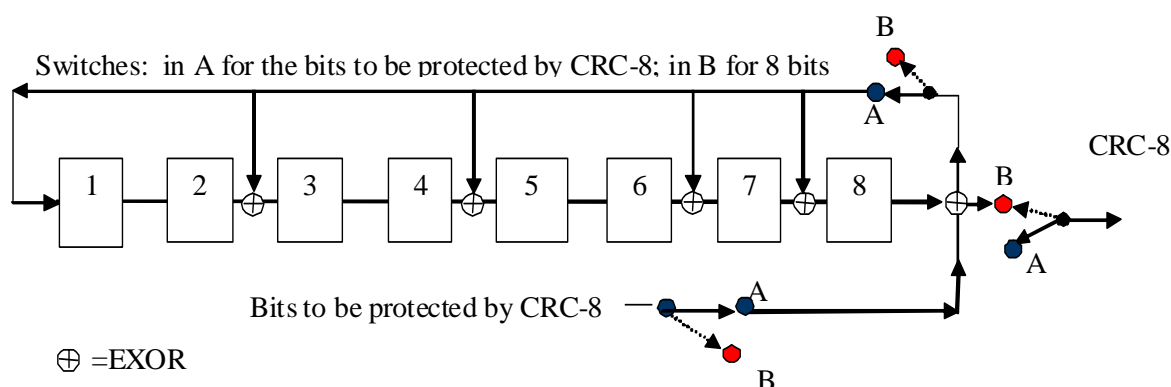

Figure 2: Implementation of the CRC-8 encoder

The MSB of the CRC shift register is MSB of the CRC byte. This CRC is "0xD5" in MSB first notation, and is equivalent to the CRC-8 with Polynomial "0xEA" in Koopman notation.

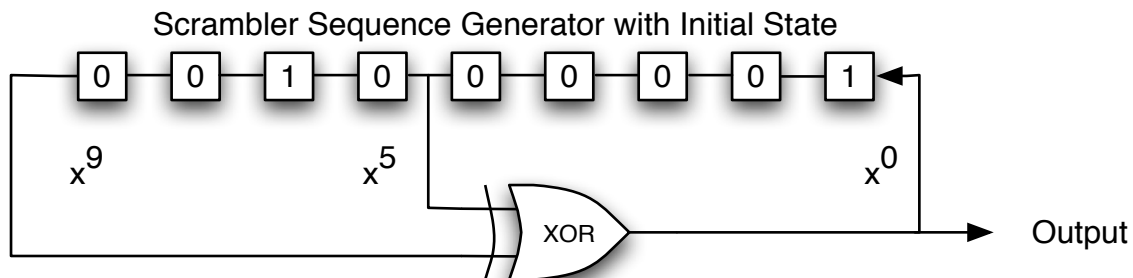NOTE: The CRC does not cover the unique word.

5.1.3   BCH FEC

The FEC is a (127, 85) 6-error correcting systematic BCH code, shortened by 16 bits to (111, 69). The encoding operation is defined as an operation involving polynomials over GF(2). The first data bit sent is the coefficient of the highest degree term in the degree 68 data polynomial D(x). The first parity bit sent is the coefficient of the highest degree term in the degree 41 parity polynomial P(x). The parity polynomial P(x) is the remainder after dividing $D(x){\cdot}x^{42}$ by the degree-42 generator polynomial $G_{BCH}(x)$. The generator polynomial is the product of the following degree-7 polynomials over GF(2) (see table 4). The parity bits are sent after the data bits.

Table 4: BCH polynomials

$g_1(x)$	$1+x^4+ x^7$
$g_2(x)$	$1+ x^2+ x^3+x^4+ x^7$
$g_3(x)$	$1+x+ x^2+ x^3+x^4+ x^5+ x^7$
$g_4(x)$	$1+ x^6+ x^7$
$g_5(x)$	$1+ x^2 +x^4 +x^6+ x^7$
$g_6(x)$	$1 +x^4 +x^5 +x^6+ x^7$
NOTE: The BCH FEC does not cover the unique word.	

5.2 Scrambling

All bits in a CID_Frame except the unique word bits are scrambled. The scrambling polynomial is: $x^9 + x^5 + 1$. The initial state is 0x41. The feedback value $x^9 + x^5$ is the output. The scrambler does not advance over the unique words. The scrambler is reset to the initial state at the start of each CID_Frame.

Scrambler Sequence Generator with Initial State

NOTE   The scrambler does not cover the unique word.

Figure 3: Message Frame Scrambler

5.3 Repetition

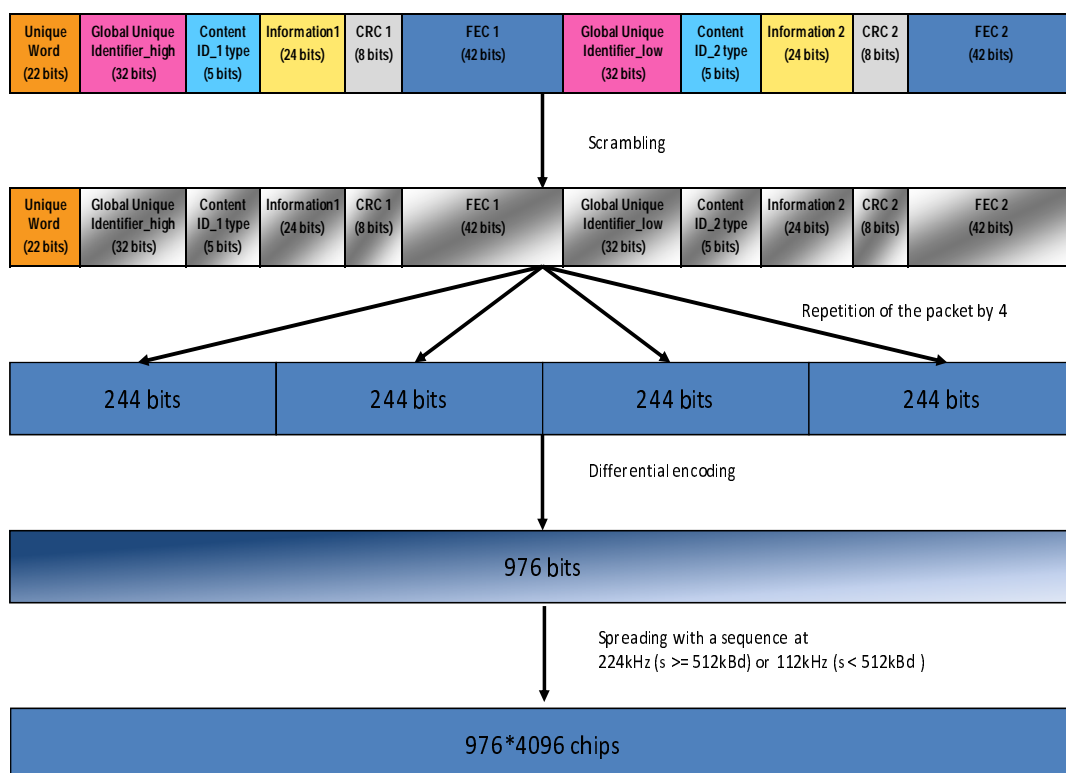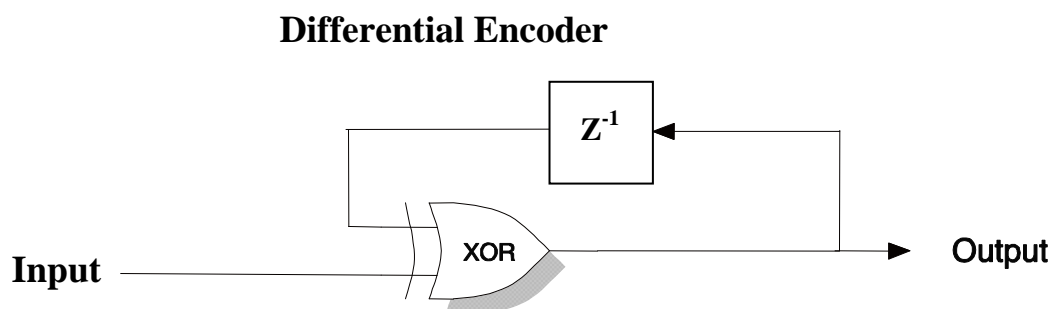The scrambled CID bits (unique word and scrambled bits) are repeated 4 times.

Figure 4: Scheme of the CID Frame

5.4   Differential encoder

All repeated CID bits are differentially encoded.

Differential Encoder

NOTE   Unique word bits are also differentially encoded.

Figure 5: Symbol Differential Encoder

5.5   Chipping

Chipping is applied on every bit after differential encoding. The chipping ratio (spreading) is 4 096 chips/bit at all supported symbol rates. Each bit is chipped using the same 4 096 bit pattern.

The chipping pattern is created using a LFSR polynomial of $x^{15} + x^{14} + 1$ with an initial state of [0 1 0 1 0 0 0 0 1 0 0 1 0 0 0]. The first 32 chips generated by the LFSR are (MSB first) 0x5091E364. The pattern is forced to repeat every 4 096 chips.
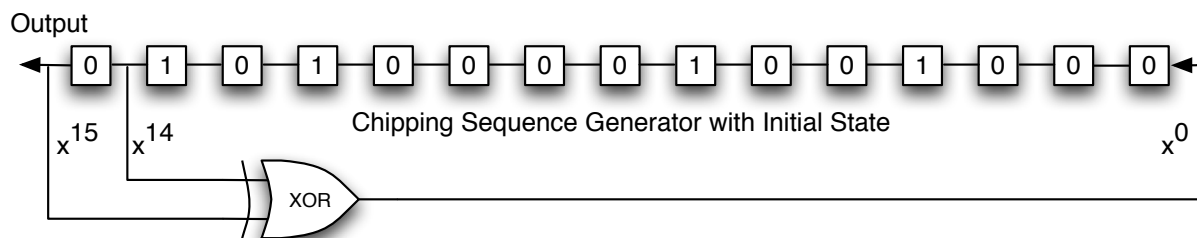

Figure 6: Chipping Sequence Generator

For host carrier symbol rate (see note) $\geq$ 512 kBd a chip rate of 224 kHz shall be used. For host carrier symbol rate < 512 kBd a chip rate of 112 kHz shall be used.

NOTE: The -3 dB Bandwidth is considered when the Symbol rate concept is not applicable.

5.6   Chip mapping into BPSK constellation

After chipping, each chip c_i of the sequence of CID_frames shall be mapped into BPSK constellation, generating a modulation symbol y_i as a complex vector in the format (I,Q) (I being the in-phase component and Q the quadrature component).

Chip mapping into the BPSK constellation shall follow figure 7. The normalized average energy per symbol shall be equal to 1.
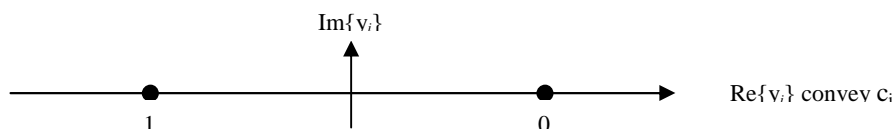
Im{v_i}

Re{v_i} convey c_i

Figure 7: Bit mapping into BPSK constellation

The exact values of the real and imaginary components Re(y_i) and Im(y_i) for each combination of the relevant input bits c_i are given in table 5.

Table 5: Constellation mapping for BPSK

c_i	1	0
Re(y_i)	-1	1
Im(y_i)	0	0

5.7   Nyquist filter

After mapping into constellation, the signal shall be square root raised cosine filtered. The roll-off factor shall be $\alpha = 0{,}35$.

The baseband square root raised cosine filter shall have a theoretical function defined by the following expression:

$$H(f) = 1 \qquad \text{for } |f| < f_N(1-\alpha)$$

$$H(f) = \left\{ \frac{1}{2} + \frac{1}{2}\sin\frac{\pi}{2f_N}\left[\frac{f_N - |f|}{\alpha} \right] \right\}^{1/2} \qquad \text{for } f_N(1-\alpha)$$

$$H(f) = 0 \qquad \text{for } |f| > f_N(1+\alpha),$$

where: $f_N = \dfrac{1}{2T_s} = \dfrac{R_s}{2}$ is the Nyquist frequency, α is the roll-off factor and R_C is the chip rate.

A template for the signal spectrum at the modulator output is given in annex A.

Modulation shall be performed by multiplying the samples (after baseband filtering) by sin ($2\pi f_0 t$) (where f_0 is the carrier frequency). The resulting signal shall be added to obtain the modulator output signal.

5.8   Gain adjust

A gain adjust has to be performed in order to produce a constant power spectral density of the DVB CID signal relative to the power spectral density of the center of the host carrier at the level as detailed in table 6. The power spectral density accuracy shall be within ±0,5 dB.

Table 6: Relative PSD levels for the DVB CID signal

Host carrier Symbol rate (s) range (see note)	DVB CID signal PSD level relative to host carrier center PSD
128 kBd ≤ s < 256 kBd	-27,5
256 kBd ≤ s < 512 kBd	-27,5
512 kBd ≤ s < 1 024 kBd	-27,5
1 024 kBd ≤ s < 2 048 kBd	-27,5
2 048 kBd ≤ s < 4 096 kBd	-24,5
4 096 kBd ≤ s < 8 192 kBd	-21,5
8 192 kBd ≤ s < 16 384 kBd	-18,5
16 384 kBd ≤ s	-17,5
NOTE: The -3 dB Bandwidth is considered when the Symbol rate concept is not applicable.	

5.9   Complex Mix

At the output of the modulator the carrier ID signal is sent at +220 Hz offset when the modulator is configured not to introduce a spectrum inversion in the host carrier signal.

At the output of the modulator the carrier ID signal is sent at -220 Hz offset when the modulator is configured to introduce a spectrum inversion in the host carrier signal.

6   DVB CID carrier phase noise specification

For chip rate 224 kHz (host carrier symbol rate ≥ 512 kBd) the close-in TX phase noise for the DVB CID signal shall be as specified in table 5, which extends the mask in [3] below 10 Hz maintaining $1/f^3$ slope down to 1 Hz.

For chip rate 112 kHz (host carrier symbol rate < 512 kBd) the close-in TX phase noise for the DVB CID signal shall be as specified in table 6.

NOTE: The -3 dB Bandwidth is considered when the Symbol rate concept is not applicable.

For both chip rates, the accuracy shall be 5 ppm/year.

Table 7: Close-in TX phase noise mask for the Carrier-ID signal for chip rate 224 kHz
(host carrier symbol rate ≥ 512 kBd)

Frequency Offset [Hz]	SSB phase noise [dBc/Hz]	SSB phase noise [dBc/Hz] after xD frequency divider D ≥ 20	Source
1	0	$-20 \cdot \log_{10}(D)$	[3] extended
10	-30		[3]
100	-60		[3]
NOTE: To avoid confusion about the interpretation of 0 dBc/Hz phase noise: The 3rd column corresponds to -26 dBc/Hz measured with an ideal spectrum analyzer after a x 20 frequency divider.			

Table 8: Close-in TX phase noise mask for the Carrier-ID signal for chip rate 112 kHz
(host carrier symbol rate < 512 kBd)

Frequency Offset [Hz]	SSB phase noise [dBc/Hz]	SSB phase noise [dBc/Hz] after xD frequency divider D ≥ 20	Source
1	-6	$-6 - 20 \cdot \log_{10}(D)$	[3] extended - 6 dB [5] extended + 6 dB
10	-36		[3] - 6 dB
100	-66		[5] + 6 dB

Annex A (normative):
Transmit filter response

Figure A.1 gives the template for the amplitude response of the CID modulator equivalent baseband Nyquist filter.
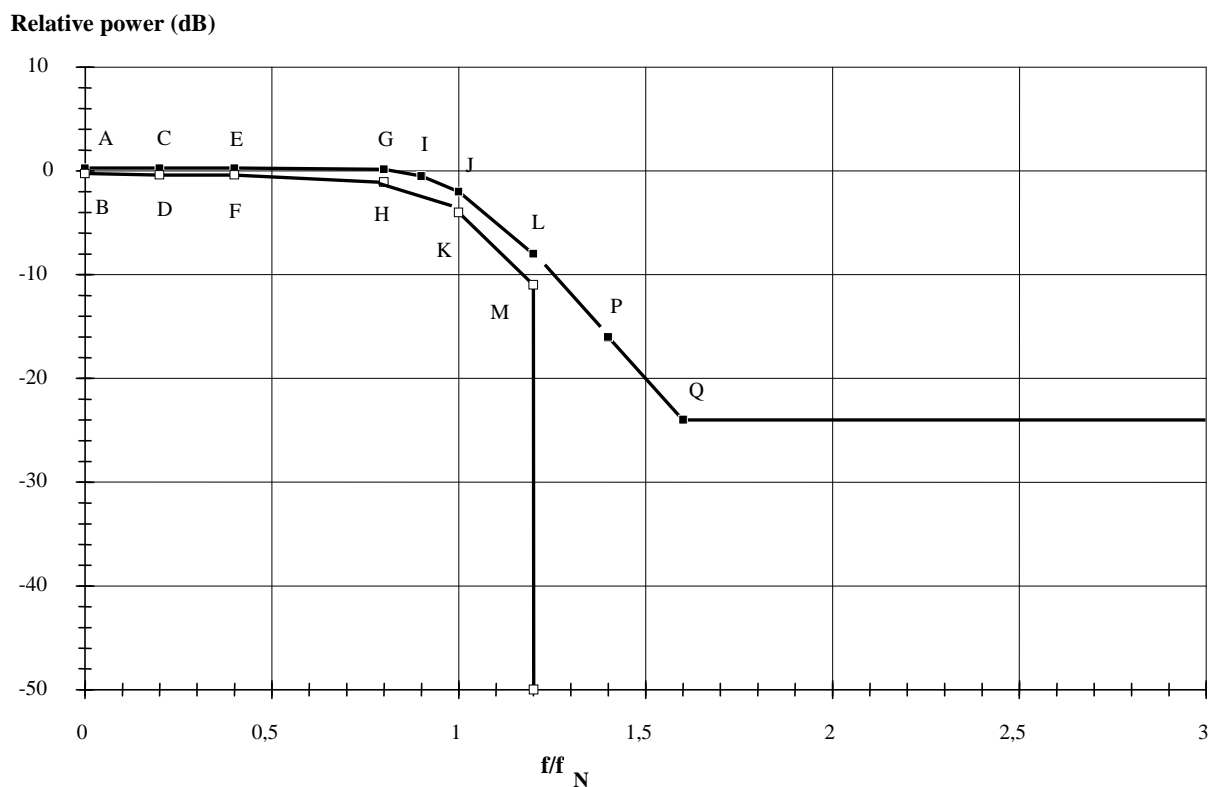
Relative power (dB)

**Figure A.1: Template for the amplitude response of the CID modulator
equivalent baseband Nyquist filter**

Figure A.2 gives the template for the group delay response of the CID modulator equivalent baseband Nyquist filter.

All filter effects up to the output of the CID modulator are understood to be included.
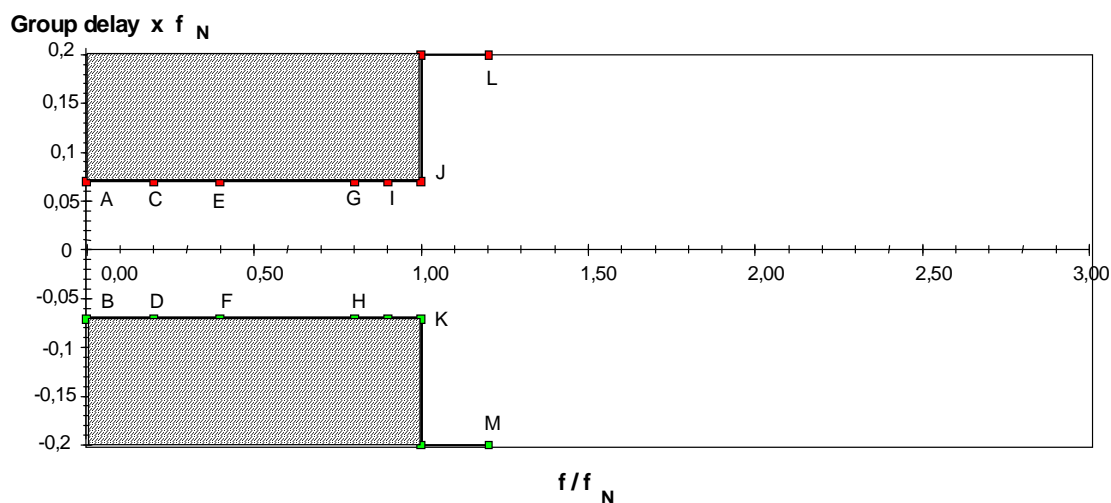

**Figure A.2: Template for the group delay response of the CID modulator
equivalent baseband Nyquist filter**

Table A.1: Definition of points given in figures A.1 and A.2

Point	Frequency	Relative power (dB)	Group delay
A	$0{,}0\ f_N$	+0,25	$+0{,}07/f_N$
B	$0{,}0\ f_N$	-0,25	$-0{,}07/f_N$
C	$0{,}2\ f_N$	+0,25	$+0{,}07/f_N$
D	$0{,}2\ f_N$	-0,40	$-0{,}07/f_N$
E	$0{,}4\ f_N$	+0,25	$+0{,}07/f_N$
F	$0{,}4\ f_N$	-0,40	$-0{,}07/f_N$
G	$0{,}8\ f_N$	+0,15	$+0{,}07/f_N$
H	$0{,}8\ f_N$	-1,10	$-0{,}07/f_N$
I	$0{,}9\ f_N$	-0,50	$+0{,}07/f_N$
J	$1{,}0\ f_N$	-2,00	$+0{,}07/f_N$
K	$1{,}0\ f_N$	-4,00	$-0{,}07/f_N$
L	$1{,}2\ f_N$	-8,00	-
M	$1{,}2\ f_N$	-11,00	-
N	$1{,}8\ f_N$	-35,00	-
P	$1{,}4\ f_N$	-16,00	-
Q	$1{,}6\ f_N$	-24,00	-

Annex B (informative):
Computation of the Degradation of the host carrier and Detectability computation

B.1   Void

B.2   Degradation of the host carrier

Degradation of signal A.: There are two effects from the CID signal that cause degradation:

1)   To maintain a fixed transmit power, the signal A carrier power is decreased by the CID signal power.

2)   The CID signal power acts as an interferer to the signal A carrier.

Degradation due to the first effect can be shown to be an order of magnitude smaller than the second effect, so the first effect often can be ignored.

The second effect can be calculated as described here. For a given link with symbol rate R_A 256 kBaud and with an overall link signal to noise and interference ratio of $SNIR_A$ of for example 19 dB, a carrier ID (CID) signal is added at a power spectral density level of -27,5 dB compared to signal power and with a chip rate R_C 112 kHz.

The resulting link degradation can be computed as follows:

$$Deg_A(\text{dB}) = 10 \log_{10} \left(1 + 10^{\frac{SNIR_A + PSD_{CID} + 10 \log_{10}\left(\frac{R_c}{R_A}\right)}{10}} \right) = 0.26 dB$$

Hence factors leading to high degradation in service A are:

•   high level of the CID signal PSD_{CID};

•   high operational $SNIR_A$ for signal A;

•   low symbol rate R_A of the main signal compared to the CID chip rate R_c.

$Deg_A(\text{dB})$ is the link degradation at receiver after the carrier CID has been added. The receiver will see the CID as additional interference contribution and the overall link $SNIR_{A+CID}$ becomes 18,74 dB.
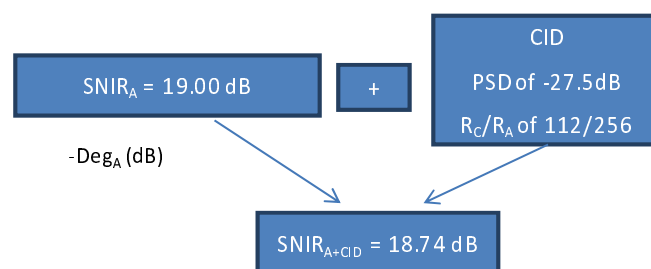

Figure B.1

The operator of the link may dispose of means to compensate for the link degradation with small changes in link parameters like the uplink power for example. In this case the overall link $SNIR_A$ needs to be changed to take into account the additional carrier ID interference contribution to the overall link budget.

The initial $SNIR_A$ of 19 dB needs to be adapted to take into account the CID contribution by the additional factor of:

$$comp\_factor\_CID_A (\text{dB}) = -10\log_{10}\left(1 - 10^{\dfrac{SNIR_A + PSD_{CID} + 10\log_{10}\left(\dfrac{R_c}{R_A}\right)}{10}}\right) = 0.277 dB$$

The compensated $SNIR_A$+comp_factor_CID_A is then 19,277 dB. This represents the target overall link budget without CID. This assuming a CID of PSD -27,5 dB and at a rate of $R_C/R_A = 112/256$ to this link will yield an overall link budget at reception of $SNIR_{A+CID}$ of 19,0 dB.
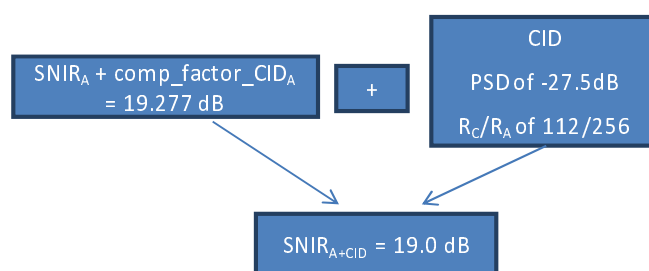

Figure B.2

B.3   Detectability computation

It is preferred to detect the identity of interferer A without interrupting the service of the interfered signal B. This requires spare margin for the interfered signal B. As a figure of merit for detectability we will computed the extra C/I to be considered in the link budget of signal B to allow identifying interferer A without switching off B. This value is well approximated by:

$$C/I = PSD_{CID} - SNR_{CID} + 10\log_{10}\left[SF\frac{\max(R_A, R_B)}{R_A}\right] - 10\log_{10}\left(1 + \frac{N_0^*}{C_{0,B}^*}\right)$$

A small correction is needed when service A and B have very similar symbol rates. Providing the exact formula would blur the main trends.

Hence factors improving detectability are:

- high level of the CID signal PSD_{CID};

- low detection threshold;

- high spreading factor SF;

- high symbol rate R_B of the interfered signal compared to the interfering signal R_A.

The last term:

$$10\log_{10}\left(1+\frac{N_0^*}{C_{0,B}^*}\right)$$

is often negligible, in particular when the interfered signal B is a broadcast service(since service B is then typically downlink limited and the E/S where carrier-ID is decoded can be expected to have much better G/T than service B terminals).

It will be noticed from the factor analysis above that the requirement for low degradation to signal A and good detectability of interference to signal B are in part opposing requirements. A better marriage of the opposing requirements is possible by selecting the value of PSD_{CID} as a function of the TX symbol rate R_A.

Annex C (informative):
Bibliography

- "Spread spectrum systems", J. Wiley.

NOTE: Available at Robert Clyde Dixon.

History

Document history		
V1.1.1	May 2013	Publication